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September 1989

TR EL-82-4

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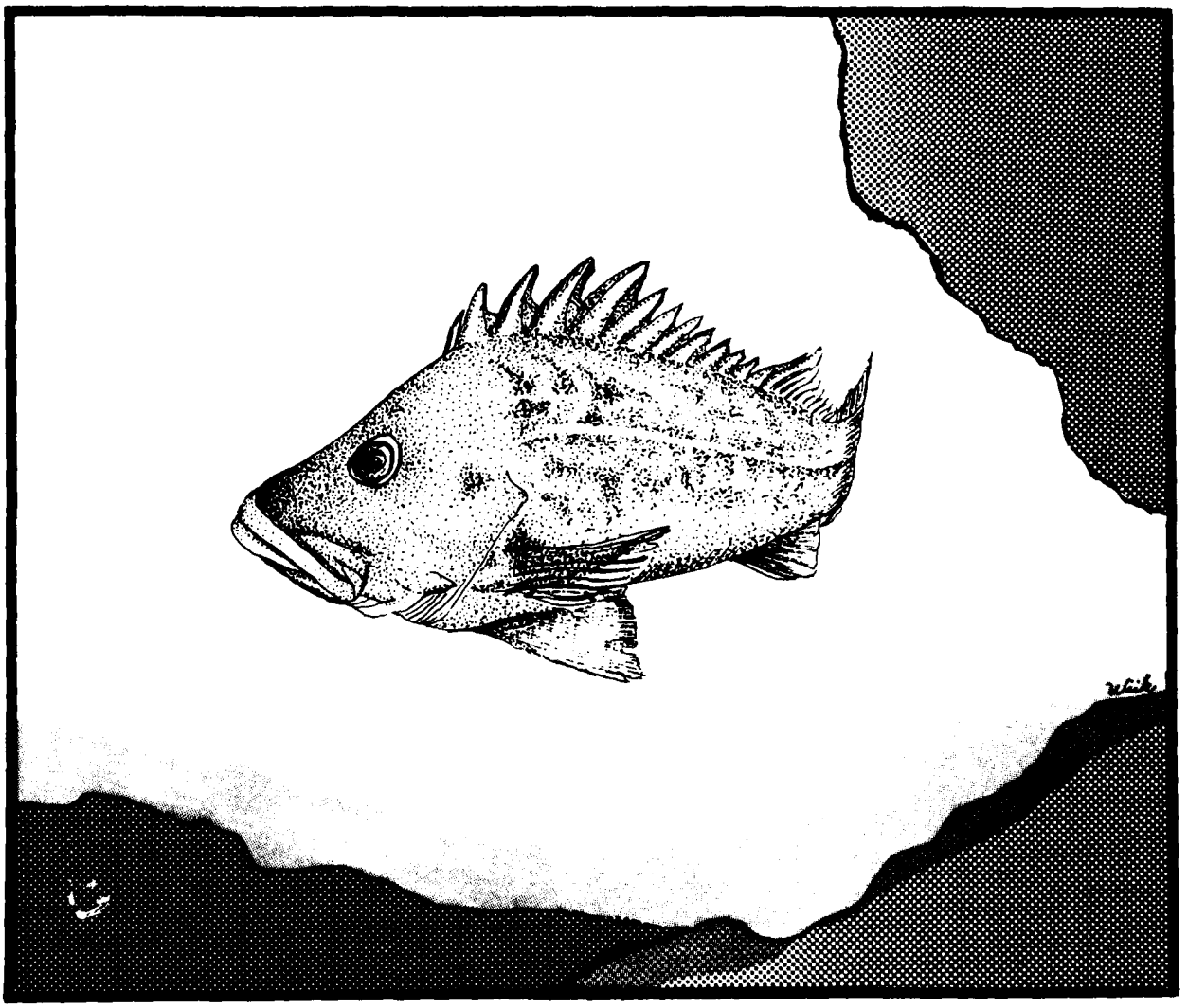

Fish and Wildlife Service
U.S. Department of the Interior

Coastal Ecology Group
Waterways Experiment Station
U.S. Army Corps of Engineers

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Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Southwest)

BROWN ROCKFISH, COPPER ROCKFISH, AND BLACK ROCKFISH

by

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PREFACE

This species profile is one of a series on coastal aquatic organisms, principally fish, of sport, commercial, or ecological importance. The profiles are designed to provide coastal managers, engineers, and biologists with a brief comprehensive sketch of the biological characteristics and environmental requirements of the species and to describe how populations of the species may be expected to react to environmental changes caused by coastal development. Each profile has sections on taxonomy, life history, ecological role, environmental requirements, and economic importance, if applicable. A three-ring binder is used for this series so that new profiles can be added as they are prepared. This project is jointly planned and financed by the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service.

Suggestions or questions regarding this report should be directed to one of the following addresses.

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CONVERSION TABLE

Metric to U.S. Customary

Multiply	By	To Obtain
millimeters (mm)	0.03937	inches
centimeters (cm)	0.3937	inches
meters (m)	3.281	feet
meters (m)	0.5468	fathoms
kilometers (km)	0.6214	statute miles
kilometers (km)	0.5396	nautical miles
square meters (m^2)	10.76	square feet
square kilometers (km^2)	0.3861	square miles
hectares (ha)	2.471	acres
liters (l)	0.2642	gallons
cubic meters (m^3)	35.31	cubic feet
cubic meters (m^3)	0.0008110	acre-feet
milligrams (mg)	0.00003527	ounces
grams (g)	0.03527	ounces
kilograms (kg)	2.205	pounds
metric tons (t)	2205.0	pounds
metric tons (t)	1.102	short tons
kilocalories (kcal)	3.968	British thermal units
Celsius degrees (°C)	1.8(°C) + 32	Fahrenheit degrees

U.S. Customary to Metric

inches	25.40	millimeters
inches	2.54	centimeters
feet (ft)	0.3048	meters
fathoms	1.829	meters
statute miles (mi)	1.609	kilometers
nautical miles (nmi)	1.852	kilometers
square feet (ft^2)	0.0929	square meters
square miles (mi^2)	2.590	square kilometers
acres	0.4047	hectares
gallons (gal)	3.785	liters
cubic feet (ft^3)	0.02831	cubic meters
acre-feet	1233.0	cubic meters
ounces (oz)	28350.0	milligrams
ounces (oz)	28.35	grams
pounds (lb)	0.4536	kilograms
pounds (lb)	0.00045	metric tons
short tons (ton)	0.9072	metric tons
British thermal units (Btu)	0.2520	kilocalories
Fahrenheit degrees (°F)	0.5556 (°F - 32)	Celsius degrees

CONTENTS

ACKNOWLEDGMENTS

We thank Dr. Ralph Larson of San Francisco State University and Dr. Milton Love of the University of California at Santa Barbara for reviewing the manuscript and for their helpful comments.

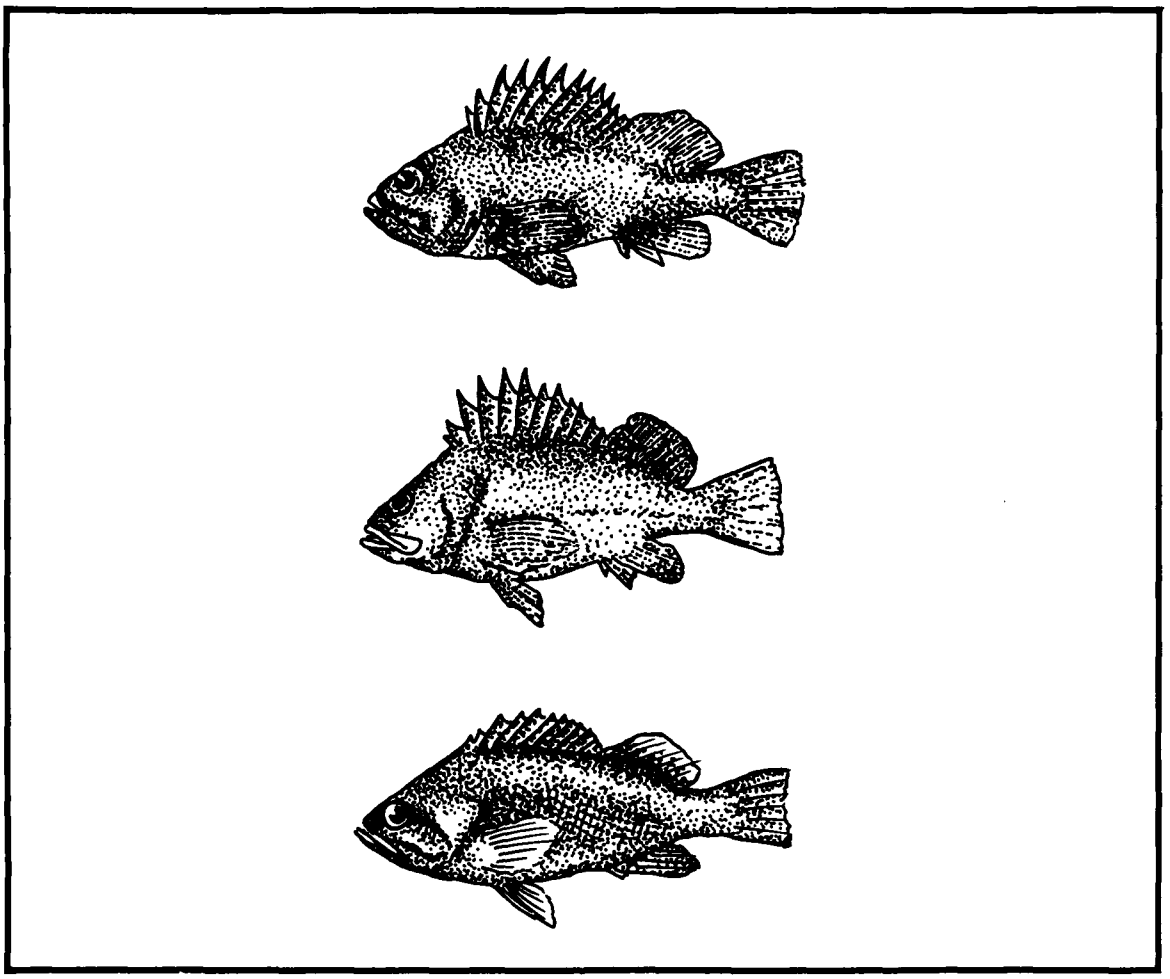

Figure 1. Brown rockfish (top), copper rockfish (middle), and black rockfish (bottom) (from Miller and Lea 1972).

BROWN ROCKFISH, COPPER ROCKFISH, AND BLACK ROCKFISH

NOMENCLATURE/TAXONOMY/RANGE

Scientific name . . . . . Sebastes auriculatus Girard
Preferred common name . . . . . .Brown rockfish (Figure 1)
Scientific name. . . . . .Sebastes caurinus Richardson
Preferred common name. . . . . .Copper rockfish (Figure 1)
Scientific name . . . . . .Sebastes melanops (Girard)
Preferred common name . . . . . Black rockfish (Figure 1)

Class . . . . . Osteichthyes
Order . . . . . Scorpaeniformes
Family . . . . . Scorpaenidae

Geographic range (from Eschmeyer et al. 1983): The brown rockfish occurs from southeastern Alaska to central Baja California, the copper rockfish from the Gulf of Alaska to central Baja California, and the black rockfish from the Aleutian Islands (Amchitka Island) to San Miguel Island, southern California (Figure 2).

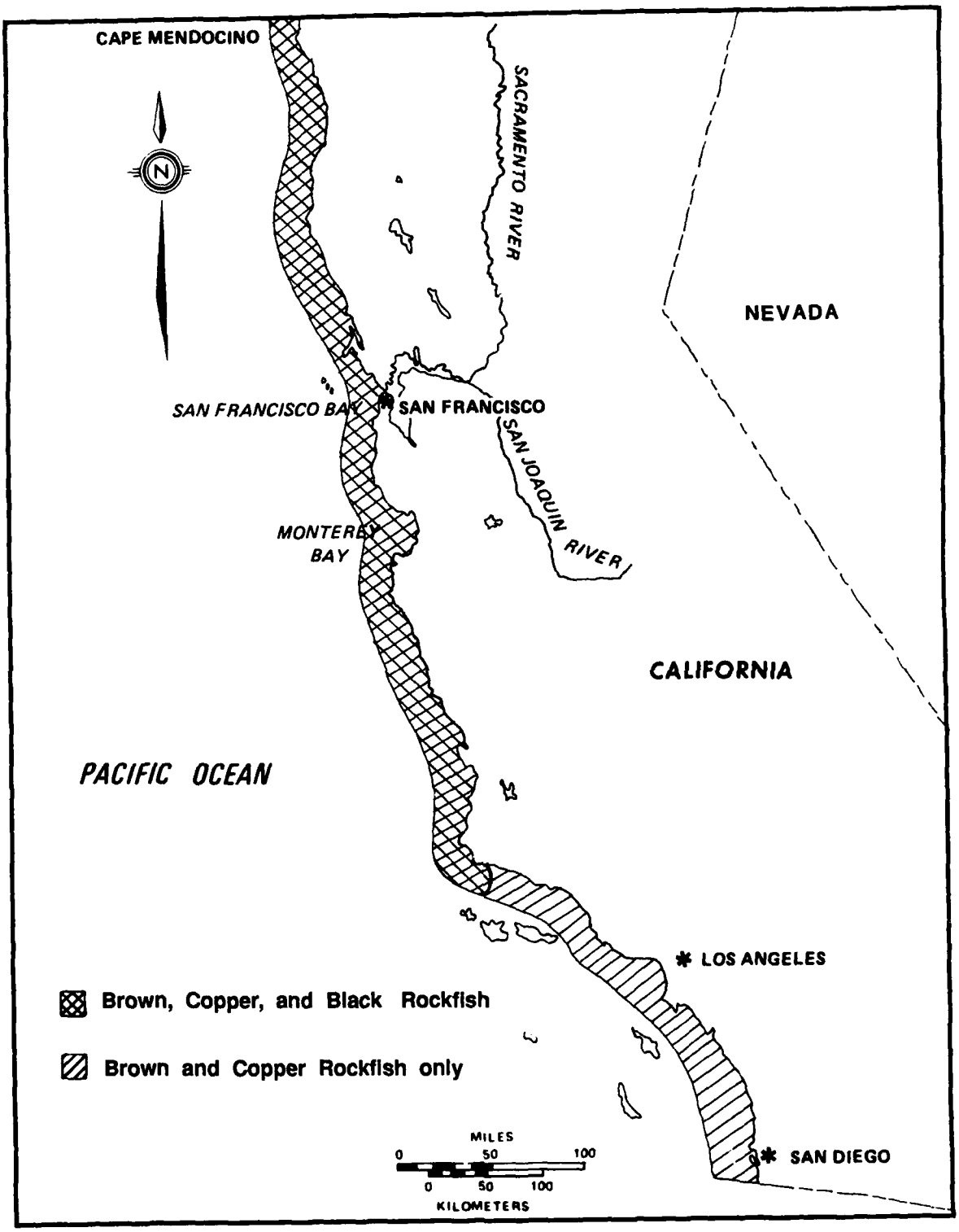

Figure 2. Distributions of brown, copper, and black rockfish.

MORPHOLOGY/IDENTIFICATION AIDS

Rockfishes off California are difficult to identify because about 60 similar species occur there. The characters given here should be used with caution. For positive identifications, consult Eschmeyer et al. (1983) and keys from Miller and Lea (1972).

Many, if not all species of Sebastes are venomous. Poison glands are associated with some or all of the spines of the first dorsal, anal, and pelvic fins. The brown rockfish is one of the few species in which poison glands are associated with all fin spines. The venom, although painful, is not dangerous except when it provokes an allergic reaction or where the injury becomes infected (Roche and Halstead 1972).

Brown rockfish. Distinguished from all other Sebastes occurring off California in having a flat interorbital space, coronal spines in most individuals (although not present in individuals from Puget Sound, Washington), light brown body with darker brown mottling, pinkish caudal, pelvic, and pectoral fin membranes, and a prominent dark brown blotch on the gill cover. Dorsal fin XIII, 12-15; anal fin III, 5-8; pectoral fin 15-19; gill raker teeth on first arch 25-30; lateral line pores 42-49.

Copper rockfish. Distinguished by the dark brown, olive, pink, or orange-red back with patches of yellow or copper-pink; the white lateral line extending from below the first dorsal fin to the tail; and the smooth underside of the lower jaw. The copper rockfish from the southern part of the species range has often been identified as S. vexillaris; recent research has shown that the two names are synonyms, and that S. caurinus has precedence (Chen 1975, 1986). Dorsal fin XIII, 11-14; anal fin III, 5-7; pectoral fin 16-18; gill raker teeth on first arch 26-32; lateral line pores 37-45.

Black rockfish. Distinguished by its body color of black or blue-black mottled with gray. First dorsal fin with black spots. Occasionally has a "dirty white" stripe along the lateral line. The upper jaw extends to or behind the eye. Dorsal fin XIII, 13-16; anal fin III, 7-9; pectoral fin 18-20; gill raker teeth on first arch 33-39; lateral line pores 46-53.

REASON FOR INCLUSION IN THE SERIES

Species of the genus Sebastes are ubiquitous off California and northward, and support important sport and commercial fisheries. In 1976, rockfish accounted for about 70% by number of all landings of ocean sport species in California and are the most important group of fish in the sport fishery (Oliphant 1979). The brown rockfish, copper rockfish, and black rockfish are all significant in the California ocean sport fishery, and the three species are also taken in the commercial fishery.

LIFE HISTORY

Spawning

Larger females produce more offspring (Echeverria 1986). The exact relationships vary with species as a power of length. All rockfishes have internal fertilization and bear live young. The young receive substantial nourishment from the mother, probably by the consumption and assimilation of ovarian fluid (Boehlert and Yoklavich 1983). Little is known of the spawning habits and early life history of the individual species because the larvae and juveniles are very difficult to identify. Echeverria (1986) suggested that courtship and insemination apparently occur over a period of at least a month, with extrusion of the

young in any one species occurring during at least a 2 month period." Individuals of most species probably spawn once a year, but in some species spawning may occur more than once (Moser 1967).

Brown rockfish. Spawning areas and times off California are unknown. Eggs and larvae from San Diego were reported and described by Eigenmann (1893). In Puget Sound, Washington, spawning occurs once a year; eggs mature and ripen in winter (DeLacy et al. 1964), and fertilization apparently occurs just after ovulation, in March and April (Hitz and DeLacy 1965). Embryos develop and are released from April to July (DeLacy et al. 1964). Females 311 mm in total length (TL; all lengths are total length unless otherwise indicated) have about 52,000 eggs, and those 477 mm long have about 339,000 (DeLacy et al. 1964). Fecundity is directly related to TL of female as follows: Fecundity = 3.6311×10^{-4} $TL^{3.34124}$ (DeLacy et al. 1964).

Copper rockfish. Little is known of the early life history. In Washington waters, spawning occurs once a year (DeLacy et al. 1964). Data on egg maturation and spawning vary: in Puget Sound, Washington, eggs mature by February (Patten 1973) or from March to May (Hitz and DeLacy 1960). Diameter of ripe eggs ranges from 0.8 to 1.1 mm (DeLacy et al. 1964). Most females had embryos in April 1959-60 (DeLacy et al. 1964) suggesting that fertilization occurs in March; however, Hitz and DeLacy (1965) suggested that it occurs in April or May. Patten (1973) suggested parturition occurs in April. As in other rockfishes, fecundity is related to length: Fecundity = 2.6095×10^{-9} $TL^{5.34656}$. Egg production ranged from 15,600 eggs in a 242-mm female to 640,000 in one 474 mm long (DeLacy et al. 1964).

Black rockfish. Spawning probably occurs once a year. Eggs developing in August have been reported (DeLacy and Dryfoos 1962). Parturition occurs from February to April off British Columbia (Hart 1973) and probably occurs in January off Oregon (Westrheim 1975). Although there are no reports from California, parturition probably occurs in January or somewhat earlier. Spawning areas are unknown. On the basis of occasional captures of spent females, however, Dunn and Hitz (1969) suggested that spawning may occur in offshore waters.

Larval Stage

Larvae and small juveniles are pelagic for periods of several months to a year (Boehlert and Yoklavich 1983). Off California they are abundant and widely distributed in the California Current (Ahlstrom and Stevens 1976; Ahlstrom et al. 1978). However, because of identification problems, the distributions of larvae and juveniles of individual species are poorly known.

Brown rockfish. Larvae have been described by Eigenmann (1893), Moser et al. (1977), Stahl and Johnson (1985), and Westrheim (1975). At birth, they are 5-6 mm long and are easily distinguished (Hitz and DeLacy 1960; Westrheim 1975).

Copper rockfish. Larvae were described by Hitz and DeLacy (1960), Moser et al. (1977), Stahl and Johnson (1985) and Westrheim (1975). Length at birth is 5-6 mm. Larvae are pelagic until they are 40-50 mm standard length (SL), and have an ontogenetic migration (Anderson 1983).

Black rockfish. Larvae and their development off Oregon are well known (Laroche and Richardson 1980, 1981). At birth, the larvae are about 5.5 mm long (Boehlert and Yoklavich 1983). The occurrence of larvae is highly seasonal; they are captured in the water column from April to June. They are pelagic at lengths less than 40-50

mm and benthic at larger sizes (Laroche and Richardson 1980).

Juveniles

Brown rockfish. Juveniles occur in shallow nearshore waters, often around piers and in bays (Miller and Gotshall 1965). Use of estuaries as nursery grounds may be unique (R. Larson, San Francisco State Univ., pers. comm.). Turner et al. (1969) reported 37-50 mm long individuals hiding in crevices of artificial reefs in Santa Monica Bay, California.

Copper rockfish. In central California, juveniles are closely associated initially with surface and mid-depth Macrocyctis kelp beds (Anderson 1983; Hallacher and Roberts 1985). Individuals become benthic at 40-50 mm long in late April and May (Anderson 1983). Off British Columbia, juveniles have been found hiding in gooseneck barnacles on flotsam (Hitz 1961); they are recruited to small artificial reefs in September and October, where at least some remain until they are 2 years old (Gascon and Miller 1981). Bays may also be used as nursery areas (Gotshall et al. 1980).

Black rockfish. In the kelp beds of Monterey Bay, California, juveniles live both in the canopy and on bottom (Miller and Geibel 1973) often associated with kelp holdfasts and sporophylls (Anderson 1983). They are recruited to the bottom primarily in June. Different color forms reflect habitat--orange when associated with kelp, darker when in the water column (Anderson 1983). Off Oregon, age 0 juveniles occur seasonally from June to October (Laroche and Richardson 1981). The June transition from pelagic to benthic habitat is marked by a distinct inshore movement to estuaries, tidepools (Moring 1972), and nearshore depths of less than 20 m (Laroche and Richardson 1980; Carlson and Straty 1981). Small juveniles thus occur in three habitats: pelagic individuals offshore at <60 mm SL in summer; nearshore on bottom at 40-70 mm SL in June; and in estuaries at 35-92 mm SL from April to October (Boehlert and Yoklavich 1983), often in eelgrass (Bayer 1981). Larger juveniles up to 15 cm long (ages I or II) may live in rocky holes, but use of these is directly reduced by competition with obligate benthic species (Gascon and Miller 1982).

Adults

Brown rockfish. Adults occur in shallow water, bays, and offshore to depths of 128 m (Eschmeyer et al. 1983), usually near bottom in rocky areas, associated with caves and crevices (Turner et al. 1969). Off southern California, however, some frequent sewer outfalls (Allen et al. 1976).

Older fish seemingly move into deeper water. Only fish of 5 years or less occur in San Francisco Bay; the older ones are offshore (Mathews and Barker 1983).

Copper rockfish. Depth ranges from surface to 183 m on rock or rocky sand bottoms (Eschmeyer et al. 1983). In Carmel Bay, California, the preferred depth was about 25 m; however, the fish were in somewhat shallower water during upwelling (Hallacher and Roberts 1985). Adults, which are closely associated with the bottom (Hallacher and Roberts 1985), never occur on sand, but are usually in and around rocks, with which they maintain much closer contact in winter and spring (Patten 1973). On an artificial reef in British Columbia, 98% of the fish seen were in contact with the bottom; less than 2% were swimming (Gascon and Miller 1982). Tagging experiments in Puget Sound have suggested that mature fish do not move far from their chosen location (Mathews and Barker 1983).

Foraging activity is reduced by high currents and turbidity such as

occur during tidal ebb and flow. At slack water, the fish move out of crevices and away from the reef (Prince 1972).

Black rockfish. Adults occur from the surface to at least 366 m, but are most abundant in water less than 54 m deep (Laroche and Richardson 1980). In Carmel Bay, California, fish usually live at depths of 12 m or less, but may be abundant as deep as 17 m during upwelling (Hallacher and Roberts 1985).

Black rockfish tend to form schools of mixed sex in midwater (Hart 1973; Echeverria 1986), especially in shallow water (Hallacher and Roberts 1985). On shallow water British Columbia reefs, schools of black rockfish occurred only from June to September (Gascon and Miller 1981). Gascon and Miller (1982) reported that 39% of the fish seen were in contact with the bottom, but 61% were swimming. The fish tend to be closer to the bottom during non-upwelling periods (Hallacher and Roberts 1985). In kelp beds, larger adults seemingly migrate outside the kelp diurnally, returning before dusk; juveniles and small adults remain in the kelp (Leaman 1977) and also tend to be closer to bottom at night (Hallacher 1977). Adults usually remain in one area, but may travel more than 600 km (Coombs 1979; Mathews and Barker 1983). Off Oregon, the larger fish tend to be in the deeper (20-50 m) water (Steiner 1979). Abundance in shallow water declines in winter and increases in summer (Gascon and Miller 1982).

Maturity and Life Span

Brown rockfish. Off central California, fish reach at least 19 years of age. Some males are sexually mature at 3 years (260 mm); all are mature at 10 years (380 mm) (Wyllie Echeverria 1987). In Puget Sound, Washington, sexual maturity is reached by 225 mm (DeLacy et al. 1964).

Copper rockfish. Off Central California, fish reach at least 20 years of age. Males may be sexually mature at 3 years of age (300 mm); all are mature by 7 years (400 mm). All females are mature by 8 years (410 mm) (Wyllie Echeverria 1987). In Puget Sound, Washington, sexual maturity usually occurs at age IV, but occasionally at III. Some females 225 mm have been reported with ripe eggs (DeLacy et al. 1964). Additional life history parameters were presented in a review by Gunderson and Dygert (1988). Average length of a mature female in an unexploited stock was 366 mm; age at 50% maturity for females was 4 years.

In a study of 20 different species of fish that included copper rockfish, the instantaneous natural mortality rate was positively correlated among species with the gonadosomatic index (gonad weight ÷ body weight), indicating that this index can predict the natural mortality rate for a fishery management model of copper rockfish (Gunderson and Dygert 1988).

Black rockfish. Off central California, fish reach at least 21 years of age. Males may be sexually mature at 3 years of age (250 mm); all are mature by 10 years (430 mm). Females may mature at 5 years (300 mm); all are mature by 11 years (480 mm) (Wyllie Echeverria 1987). Off Oregon, sexual maturity occurs at 5 years in males and 6 years in females (McClure 1982). The Oregon Department of Fish and Wildlife considers 50% of fish 400 mm fork length (FL) to be sexually mature (Coombs 1979).

GROWTH CHARACTERISTICS

Brown rockfish. Maximum length is 55 cm (Eschmeyer et al. 1983). Little is known about growth. In San Francisco Bay, daily growth of fish 150-260 mm long ranged from 0.1460 to 0.1927 mm. Winter was a period of stress and reduced growth owing to

reduced availability of food and consequently decreased body fat reserves (Adams and Ryan 1982).

Copper rockfish. Maximum length is 57 cm (Eschmeyer et al. 1983). Length-weight relations are similar for males and non-gravid females but change seasonally. Weight (g) = 1.6231×10^{-5} $FL^{3.040252}$, from September to November; and = 2.4945×10^{-5} $FL^{2.53381}$ from December to March (Patten 1973).

Little is known about growth. Growth rates are fastest in fish of age III or younger in Puget Sound, Washington (Patten 1973) as well as in Monterey Bay, California, where monthly growth ranged from 58 mm in a fish 200 mm long to 24 mm in a 320-mm fish (Miller and Geibel 1973). In Humboldt Bay, California, fish were 110-155 mm long as underyearlings, 138-196 mm at age I, 172-231 mm at age II, and 220-300 mm at age III. Growth rates were highest in summer, coinciding with high feeding rates (Prince and Gotshall 1976) and upwelling. A review by Gunderson and Dygert (1988) presents von Bertalanffy growth parameters of 0.12 for K (growth rate) and 500 mm for L_∞ (asymptotic size); longevity was 19 years.

Black rockfish. Maximum length is 60 cm (Eschmeyer et al. 1983). Length-weight relation for fish off Oregon was weight (g) = 2.5×10^{-5} $FL^{2.922}$ for males and = 1.17×10^{-5} $FL^{3.126}$ for females (McClure 1982).

The age-length relation was described by Six and Horton (1977), McClure (1982) and Echeverria (1986). Six and Horton calculated von Bertalanffy equations of: $FL=50.3[1-e^{-0.23386(age+0.4622)}]$ for males and $FL=57.8[1-e^{-0.16842(age+0.7426)}]$ for females. After age VII, females were always larger than males of the same age; females reached slightly larger sizes than males (550 mm FL vs 500 mm FL) (Six and Horton 1977; Echeverria 1986).

Growth rates are directly related to temperature, if food is abundant. Juveniles may select higher temperatures, which maximizes growth (Boehlert and Yoklavich 1983). Coombs (1979) reported that winter-caught fish were distinctly smaller than those captured in summer and fall, and speculated on possible reasons why.

THE FISHERY

The 60 species of rockfishes that live in California coastal waters support important commercial and sport fisheries. Rockfish are caught commercially with trawls, gill nets and with hook-and-line (Lenarz 1986). In 1985, the California landings were about 12,200 t, worth $8.4 million to the fishermen in the trawl fishery; 2,800 t, with an estimated value of several million dollars in the gill-net fishery; and about 1,100 t, valued at 1-2 million dollars in the hook-and-line fishery.

Rockfish account for about 34% by weight of all sport fish landed in California and are the most important group of fish caught (Lenarz 1986). In 1984, sport anglers in California landed an estimated 8 million rockfish (about 4,000 t); the value of the sport fishery, when estimated costs associated with fishing trips were included, was about $1 billion.

Brown rockfish. These fish were once caught incidentally by commercial fishermen, usually in lobster traps (Feder et al. 1974) or by salmon trollers (Miller and Gotshall 1965). Recently, however, the brown rockfish has become the most important commercial rockfish in San Franciso Bay; it is used to supply restaurants and commands a high price (Lenarz 1986).

Brown rockfish are also important in the summer sport fishery in kelp beds (Ahlstrom et al. 1978). Most are caught from party boats or skiffs (Miller and Gotshall 1965). Quast

(1968a) calculated a density exceeding 1.3 lb/acre in a southern California kelp bed.

Copper rockfish. Among species in the ocean sport fishery off California from 1957 to 1961, copper rockfish ranked 18th by number and 12th by weight (Miller and Gotshall 1965). Catches of copper rockfish in experimental trawls off southern California did not exceed 0.1% of the total number of rockfish caught (Mearns et al. 1980)--probably because the rocky areas that copper rockfish prefer are difficult to trawl.

Black rockfish. The black rockfish is the most important of the three species treated here in both the commercial and sport fisheries. The commercial fishery off California yielded 44.5 t of black rockfish in 1985. Of the 46 species caught in the sport fishery in 1984, 3--the blue rockfish (Sebastes mystinus), black rockfish, and yellowtail rockfish (Sebastes flavidus)--accounted for 34% of the catch by weight (Lenarz 1986). Black rockfish ranked 12th by number and 8th by weight for all species in the sport fish catch between Oregon and Point Arguello, California, despite being of only minor importance in the catch south of Monterey (Mille and Gotshall 1965).

The black rockfish has been the subject of many studies of processing and preservation, including preparation (Babbitt et al. 1976; Patashnik et al. 1974, 1976; Adu et al. 1983), storage (Miyauchi et al. 1975; Collins et al. 1980), and spoilage (Miller et al. 1973; Miller et al. 1973a,b).

ECOLOGICAL ROLE

Many of the rockfish species occur together. Substantial evidence suggests that co-occurring species have evolved to avoid competition with each other for limiting resources such as food, shelter and space, or to increase fitness by ecological specialization (Hallacher 1977; Steiner 1979; Larson 1980; Hallacher and Roberts 1985).

Juveniles of all species occurring in central California kelp beds are eaten by many fish, including lingcod, Ophiodon elongatus; wolf-eels, Anarrhichthys ocellatus; and cabezon, Scorpaenichthys marmoratus (Hallacher 1977).

All three species probably produce and detect sound by using extrinsic muscles associated with the swimbladder. The sounds of copper rockfish and black rockfish, which have been recorded, are apparently associated with agonistic displays such as territorial defense (Hallacher 1974).

Brown rockfish. The diet of the brown rockfish consists of crabs and small fish (Feder et al. 1974), and shrimp, isopods, and polychaetes (Quast 1968b). In Humboldt Bay, California, fish 141-300 mm long ate 40% shrimp (by volume) and 33% crabs (Prince 1972).

Brown rockfish are known to be hosts of 3 copepods, 1 digenean, 2 monogeneans, and 2 nematodes (Love and Moser 1983).

Copper rockfish. These fish are opportunistic carnivores that feed largely on benthic organisms--primarily crustaceans, fish, and molluscs (Larson 1972; Prince 1972; Patten 1973; Prince and Gotshall 1976). Food type is related to size. The smaller fish (<45 mm SL) in the kelp canopy eat primarily calanoid copepods, with some harpacticoids and zoea (Singer 1985). Fish 110-155 mm eat small crustaceans such as amphipods, shrimp, caprellids, and isopods (Prince and Gotshall 1976; Singer 1985) and pinnixid crabs (Prince 1975); 1- to 3-year-olds eat juvenile Dungeness crabs (Cancer

magister) and anchovies, with fish increasing and crustaceans decreasing as the fish grow (Prince 1972; Patten 1973). In Puget Sound, Washington, fish > 300 mm FL ate mostly fish (Patten 1973). The largest ones (>400 mm) were especially aggressive feeders; spiny dogfish appeared to be a common prey (Bargmann 1977). The fish apparently feed both during the day and at night. Prey varies seasonally; crabs were less abundant in stomachs in winter and early spring than in other seasons (Prince 1972).

Copper rockfish are apparently eaten by seals and lingcod (Prince 1972) and probably by other large predators.

Competitive interactions are unclear. Gascon and Miller (1982) found that the use of space on a small reef seemed unaffected by the abundances of other species, and Hallacher (1977) concluded that copper rockfish "frequent a particular locality at least during part of the year" but probably have a wider home range than co-occurring congeners. In both studies, however, copper rockfish were not abundant enough to support adequate observations. Prince (1972) concluded from diving observations that individual copper rockfish display agonistic behavior to show "protective territoriality."

Copper rockfish are hosts of many endoparasites and ectoparasites, including 2 branchiurans, 3 cestodes, 2 acanthocephalans, 6 nematodes, 1 hirudinoid, 9 copepods, 3 monogeneans, 13 digeneans, and 1 protozoan (Sekerak and Arai 1977; Love and Moser 1983).

Black rockfish. Food off Oregon is primarily pelagic nekton (smelt, anchovies) and zooplankton such as salps, mysids, and crab megalops (Steiner 1979). Black rockfish also eat kelp clingfish, Rimicola muscarum (Roland 1978). Off Oregon in the spring, crab megalops make up 25% of the diet by weight (Steiner 1979). Off central California, juveniles ate copepods and zoea (Singer 1985). Adult prey was primarily juvenile rockfish (73% of stomach contents by weight), euphausiids, and amphipods during upwelling periods, but at other times primarily invertebrates (Hallacher and Roberts 1985). The percent of empty stomachs during non-upwelling periods was nearly double that during upwelling. In addition, food overlap with co-occurring congeners decreased during non-upwelling periods, suggesting that food may then be a limiting factor for rockfish occurring in kelp forests (Hallacher and Roberts 1985). Most feeding is probably during the day and at twilight (Hallacher 1977). The rate of gastric evacuation of ingested squid and fish (dry weight) is about 6% per hour--about 76 hours are required for stomach clearance (Brodeur 1984).

Black rockfish are known to be eaten by lingcod and yelloweye rockfish Sebastes ruberrimus (Steiner 1979).

Competitive relations are poorly known. As expected, from their midwater habitat, there is little competition for food with benthic species (Steiner 1979). Off California, Hallacher (1977) found that the diet of black rockfish was unlike that of other rockfishes with which it had synchronous spatial overlap, but he was unable to explain its actual competitive relations with these species. Benthic black rockfish compete with other species for hiding places; the abundance of juvenile black rockfish on small reefs decreases as that of several other species increases (Gascon and Miller 1982).

Parasites include leeches on fins and body in Oregon (Burreson 1977); and a myxosporidean in the heart in central California (Moser et al. 1976) In all, 5 copepods, 6 diageneans, 2 hirudinoids, 2 monogeaneans, and 1

protozoan have been reported (Love and Moser 1983).

ENVIRONMENTAL REQUIREMENTS

Temperature

Brown rockfish. Because brown rockfish occur in shallow water, they are exposed to a relatively broad range of seasonal temperature variations, of at least 10^{0} C to 17^{0} C (Turner et al. 1969). Their capacity for acclimation is higher than that of rockfishes living below the thermocline and they can tolerate higher temperatures--to at least 22^{0} C (Wilson et al. 1974). Occurrence in estuaries and oceanic waters suggests relatively broad salinity tolerance (R. Larson, San Francisco State Univ., pers. comm.).

Copper rockfish. No specific information is available on temperature requirements of copper rockfish; however, their depth range is relatively broad, and the minimum depth decreases seasonally with upwelling (Hallacher and Roberts 1985)--suggesting that lower temperatures are preferred (although a broad range can be tolerated).

Black rockfish. No specific temperature data are available for adults. Juveniles occur at water temperatures of 8 to 18^{0} C (Boehlert and Yoklavich 1983). Black rockfish are more closely associated with the bottom during non-upwelling seasons (Hallacher and Roberts 1985) suggesting that the warmer surface waters may not then be suitable for adults; however, this behavior could also be a result of decreased food in the water column.

Depth

The brown rockfish occurs in bays and nearshore waters to depths of 128 m, the copper rockfish on the bottom from shallow water to 183 m, and the black rockfish from the surface to 366 m (Eschmeyer et al. 1983). Small black rockfish tend to be epibenthic, and the larger ones occur well up in the water column, usually near or in such shelter as kelp or pilings--though they may live in deeper waters in winter (Moulton 1977). Black rockfish off Oregon (Steiner 1979) and off California (Miller and Geibel 1973) were relatively much more abundant on shallow reefs than on deeper ones.

Substrate

Although habitats of different rockfish species are separated by depth and substrate type, Gascon and Miller (1981) concluded that "habitat selection is based primarily on bottom shape (shelter) and secondarily on depth." Shelter is particularly important for brown and copper rockfishes, which are usually associated with it.

Brown rockfish are closely associated with rocky substrates and kelp beds, copper rockfish are primarily on rocky reefs or rock-sand bottom of irregular bathymetry, and black rockfish are primarily in midwater--usually in kelp or around cover such as pilings and piers, although they are occasionally offshore in open waters. A significant proportion of (usually smaller) black rockfish are benthic on rocky bottom. Data on shelter-seeking is conflicting. Hallacher and Roberts (1985) stated that the fish do not occupy holes in the bottom even if competing demersal species are removed, whereas Gascon and Miller (1982) found that fish 6-15 cm long sheltered in holes. These behaviors may be related to size.

Other Environmental Factors

No information is available on dissolved oxygen requirements, salinity tolerances, or effects of water currents or turbidity for these rockfishes, and their sensitivity to habitat alterations is unknown.

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15. Supplementary Notes

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16. Abstract (Limit: 200 words)

Species profiles are literature summaries of the taxonomy, morphology, range, life history, and environmental requirements of coastal aquatic species. They are designed to assist in environmental impact assessment. Rockfishes are the basis of very important sport and commercial fisheries in the northeastern Pacific. Exploitation is increasing. Brown rockfish (Sebastes auriculatus), copper rockfish (S. caurinus), and black rockfish (S. melanops) are three important members of this family. Two of the species occur throughout the Pacific Southwest region; the black rockfish occurs only from about Santa Barbara northward. The habitats and foods differ significantly among species, although at certain times and places they may overlap. Black rockfish tend to be pelagic; the other two species are benthic. Their foods generally reflect these differences in habitats. These species may compete with one another and with other rockfish and benthic species for habitat. The environmental factors determining distribution, growth, and survival are generally unknown. All rockfish have internal fertilization and bear live young. The reproductive behavior, spawning times, and spawning areas of these species are poorly known, although larvae of all have been described. Growth patterns are not well understood. All three species are apparently rather long-lived.

17. Document Analysis a. Descriptors

Fishes
Fisheries
Feeding habits
Life cycles
Estuaries
Growth
Temperature
Depth

b. Identifiers/Open-Ended Terms

Life history
Brown rockfish
Sebastes auriculatus
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